REMARKS

Claims 12-19 and 21-31 are all the claims pending in the application. Claim 20 is canceled above and claims 23-31 are added above to further define the invention. Claims 12-19, 21, and 22 stand rejected on prior art grounds. Claims 12, 14 and 18 stand objected to upon informalities. Applicants respectfully traverse these objections/rejections based on the following discussion.

I. The Objections to the Claims

Claims 12, 14, and 18 are objected to because of topographical errors. The typographical errors have been corrected as suggested in the Office Action. In view of the foregoing, the Examiner is respectfully requested to withdraw these objections.

II. The Prior Art Rejections

Claims 12, 16-20 stand rejected under 35 U.S.C. §102(b) as being anticipated by Mandelman, et al. (U.S. Patent No. 6,455,886), hereinafter referred to as Mandelman '886. Claims 12, 16-20 stand rejected under 35 U.S.C. §102(b) as being anticipated by Mandelman, et al. (U.S. Patent No. 6,555,862), hereinafter referred to as Mandelman '862. Claim 12 stands rejected under 35 U.S.C. §102(b) as being anticipated by Chang, et al. (U.S. Patent No. 10/688,612

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6,696,717), hereinafter referred to as Chang. Claims 18-19 and 21 stand rejected under 35 U.S.C. §102(b) as being anticipated by Divakaruni, et al. (U.S. Patent No. 6,420,750), hereinafter referred to as Divakaruni. Claims 13-15 and 21-22 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Mandelman '886, in view of M'Saad (U.S. Patent No. 6,013,584). Claims 13-15 and 21-22 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Mandelman '862, in view of M'Saad. Claims 13-15 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Chang, in view of M'Saad. Claim 22 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Divakaruni, in view of M'Saad. Applicants respectfully traverse these rejections based on the following discussion.

A. The Rejection Based on Mandelman '886

Applicants respectfully traverse this rejection because Mandelman '886 only discloses an initial heating process that forms the conductive strap and does not disclose the additional claimed heating process that is performed after the first conductive strap is formed and that forms the second conductive strap of the claimed invention.

More specifically, as explained in column 5, line 29-column 6, line 21, of Mandelman '886, heating processes that form the trench top oxide 116a are utilized to diffuse impurities from the arsenic silicon glass layer 112 and the polysilicon strap 110 to form the source/drain diffusion regions 118 (see Figure 9 of Mandelman '886). In Mandelman '886 there are no additional heating processes that would allow a second conductive strap to be formed from dopants

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diffusing out from the trench top oxide 116a. Indeed, in Mandelman '886 the trench top oxide 116a is undoped, and is only used as an insulator and not a source of impurities. To the contrary, in the claimed invention, after the conductive buried strap and trench top oxide are formed, the structure is subjected to a second heating process that outdiffuses dopants from the trench top oxide to form a second conductive buried strap in the substrate that is connected to the first buried strap. More specifically the independent claims define this process using the following language: "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" independent claims 12 and 18.

Thus, the invention utilizes multiple heating steps to form the different portions of the buried strap, which allows lower temperature processes to be applied. With the invention, the higher temperatures normally needed to cause a larger buried strap outdiffusion can be avoided because the buried strap outdiffusion does not need to be as large with the invention. Normally, the buried strap outdiffusion needs to be made large enough to make the silicon next to the trench top oxide conductive. However, the inventive multiple heating step approach and doped trench top oxide outdiffusion allows the buried strap outdiffusion to be smaller (utilizing lower temperature thermal cycles) by providing a separate conductive region adjacent the trench top oxide. Thus, the temperature of the thermal cycles (thermal budget) can be reduced. To the contrary, conventional processes that only rely upon outdiffusion from the trench conductor and the node strap to form the buried strap must use substantially higher temperatures to achieve a conductive region adjacent the trench top oxide.

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To further shrink the vertical DRAM cell, the lateral and vertical outdiffusion from the polysilicon strap is reduced (using lower temperature thermal cycles) to avoid interaction between adjacent DRAM cells while still maintaining a low resistive path to the channel region of the vertical transistor. Along with reducing the outdiffusion from the conductive strap, the invention outdiffuses dopant from the doped trench top oxide layer to ensure that a conductive path exists from the capacitor conductor to the channel. To assure good isolation between the conductors, and sufficient process control for the oxide deposition, the trench top oxide, should have a certain thickness. Considering that the process tolerance is +/- 100a, sufficient overlap between the conductive region and transistor channel is not assured with conventional processes that only rely upon outdiffusion from the trench conductor and the node strap. This is why at least a portion of the trench top oxide is doped in the inventive structure. The inventive trench top oxide deposition process was developed to provide good dopant control in the oxide, to consistently achieve this structure.

To further shrink the vertical DRAM cell, with the invention, the lateral outdiffusion of the buried strap is reduced to avoid interaction between adjacent DRAM cells, while still maintaining a low resistive path to the channel region of the vertical transistor. By reducing the thermal budget of the entire process through multiple heating steps, the invention outdiffuses dopant from the doped trench top oxide layer and reduces the outdiffusion of the buried strap. Thus, both lateral and vertical outdiffusions are reduced. Sufficient overlap between the buried strap and the transistor channel is not assured with conventional processes that only rely upon outdiffusion from the trench conductor and the node strap to form the buried strap. This is why a

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portion of the trench top oxide is doped in the inventive structure.

Therefore, as shown above, Mandelman '886 does not teach or suggest many of the claimed features in the invention including "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" as defined by independent claims 12 and 18. Therefore, Applicants submit that independent claims 12 and 18 are not anticipated by Mandelman '886 and are patentable over Mandelman '886. Further, dependent claims 16, 17, and 19 are similarly patentable, not only because they depend from a patentable independent claim, but also by virtue of the additional features of the invention they define. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

B. The Rejection Based on Mandelman '862

Applicants respectfully traverse this rejection because Mandelman '862 only discloses an initial heating process that forms the conductive strap and does not disclose the additional claimed heating process that is performed after the first conductive strap is formed and that forms the second conductive strap of the claimed invention.

More specifically, as explained in column 5, lines 5-27, of Mandelman '862, the heating processes involved with the formation of the sacrificial oxide 134 and the gate that electric 140 create strap diffusion region 135. In Mandelman '862 there are no heating processes that would

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allow a second conductive strap to be formed from dopants diffusing out from the trench top oxide 128. Indeed, in Mandelman '862 the trench top oxide 128 is undoped, and is only used as an insulator and not a source of impurities. In Mandelman '862, the only source of dopants for the diffusion region 135 are the storage node 110, the buried strap 112, and the glass layer 120 (column 5, lines 13-15). Further, these sources of impurities all simultaneously contribute dopants to the diffusion region 135, while the invention forms the first conductive strap while forming the trench top oxide and then, in a subsequent step, after the first conductive strap is formed, outdiffuses dopants from the trench top oxide. Thus, in the claimed invention, after the conductive buried strap and trench top oxide are formed, the structure is subjected to a second heating process that outdiffuses dopants from the trench top oxide to form a second conductive buried strap in the substrate that is connected to the first buried strap. More specifically the independent claims define this process using the following language: "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" independent claims 12 and 18.

Thus, the invention utilizes multiple heating steps to form the different portions of the buried strap, which allows lower temperature processes to be applied. With the invention, the higher temperatures normally needed to cause a larger buried strap outdiffusion can be avoided because the buried strap outdiffusion does not need to be as large with the invention. Normally, the buried strap outdiffusion needs to be made large enough to make the silicon next to the trench top oxide conductive. However, the inventive multiple heating step approach and doped trench

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top oxide outdiffusion allows the buried strap outdiffusion to be smaller (utilizing lower temperature thermal cycles) by providing a separate conductive region adjacent the trench top oxide. Thus, the temperature of the thermal cycles (thermal budget) can be reduced. To the contrary, conventional processes that only rely upon outdiffusion from the trench conductor and the node strap to form the buried strap must use substantially higher temperatures to achieve a conductive region adjacent the trench top oxide.

To further shrink the vertical DRAM cell, the lateral and vertical outdiffusion from the polysilicon strap is reduced (using lower temperature thermal cycles) to avoid interaction between adjacent DRAM cells while still maintaining a low resistive path to the channel region of the vertical transistor. Along with reducing the outdiffusion from the conductive strap, the invention outdiffuses dopant from the doped trench top oxide layer to ensure that a conductive path exists from the capacitor conductor to the channel. To assure good isolation between the conductors, and sufficient process control for the oxide deposition, the trench top oxide, should have a certain thickness. Considering that the process tolerance is +/- 100a, sufficient overlap between the conductive region and transistor channel is not assured with conventional processes that only rely upon outdiffusion from the trench conductor and the node strap. This is why at least a portion of the trench top oxide is doped in the inventive structure. The inventive trench top oxide deposition process was developed to provide good dopant control in the oxide, to consistently achieve this structure.

To further shrink the vertical DRAM cell, with the invention, the lateral outdiffusion of the buried strap is reduced to avoid interaction between adjacent DRAM cells, while still

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maintaining a low resistive path to the channel region of the vertical transistor. By reducing the thermal budget of the entire process through multiple heating steps, the invention outdiffuses dopant from the doped trench top oxide layer and reduces the outdiffusion of the buried strap. Thus, both lateral and vertical outdiffusions are reduced. Sufficient overlap between the buried strap and the transistor channel is not assured with conventional processes that only rely upon outdiffusion from the trench conductor and the node strap to form the buried strap. This is why a portion of the trench top oxide is doped in the inventive structure.

Therefore, as shown above, Mandelman '862 does not teach or suggest many of the claimed features in the invention including "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" as defined by independent claims 12 and 18. Therefore, Applicants submit that independent claims 12 and 18 are not anticipated by Mandelman '862 and are patentable over Mandelman '862. Further, dependent claims 16, 17, and 19 are similarly patentable, not only because they depend from a patentable independent claim, but also by virtue of the additional features of the invention they define. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

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C. The Rejection Based on Chang

Applicants respectfully traverse this rejection because Chang only discloses an initial heating process that forms the conductive strap and does not disclose the additional claimed heating process that is performed after the first conductive strap is formed and that forms the second conductive strap of the claimed invention.

More specifically, as explained in column 2, line 57-column 3, line 26, of Chang, a doped glass is formed on the sidewalls of the trench, and then a thermal diffusion process is utilized to form the strap 107. Then, the trench top oxide 112 is deposited. In Chang there are no additional heating processes that would allow a second conductive strap to be formed from dopants diffusing out from the trench top oxide 112. Indeed, in Chang the trench top oxide 112 is undoped, and is only used as an insulator and not a source of impurities. To the contrary, in the claimed invention, after the conductive buried strap and trench top oxide are formed, the structure is subjected to a second heating process that outdiffuses dopants from the trench top oxide to form a second conductive buried strap in the substrate that is connected to the first buried strap. More specifically the independent claims define this process using the following language: "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" independent claim 12.

Thus, the invention utilizes multiple heating steps to form the different portions of the buried strap, which allows lower temperature processes to be applied. With the invention, the

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higher temperatures normally needed to cause a larger buried strap outdiffusion can be avoided because the buried strap outdiffusion does not need to be as large with the invention. Normally, the buried strap outdiffusion needs to be made large enough to make the silicon next to the trench top oxide conductive. However, the inventive multiple heating step approach and doped trench top oxide outdiffusion allows the buried strap outdiffusion to be smaller (utilizing lower temperature thermal cycles) by providing a separate conductive region adjacent the trench top oxide. Thus, the temperature of the thermal cycles (thermal budget) can be reduced. To the contrary, conventional processes that only rely upon outdiffusion from the trench conductor and the node strap to form the buried strap must use substantially higher temperatures to achieve a conductive region adjacent the trench top oxide.

To further shrink the vertical DRAM cell, the lateral and vertical outdiffusion from the polysilicon strap is reduced (using lower temperature thermal cycles) to avoid interaction between adjacent DRAM cells while still maintaining a low resistive path to the channel region of the vertical transistor. Along with reducing the outdiffusion from the conductive strap, the invention outdiffuses dopant from the doped trench top oxide layer to ensure that a conductive path exists from the capacitor conductor to the channel. To assure good isolation between the conductors, and sufficient process control for the oxide deposition, the trench top oxide, should have a certain thickness. Considering that the process tolerance is +/- 100a, sufficient overlap between the conductive region and transistor channel is not assured with conventional processes that only rely upon outdiffusion from the trench conductor and the node strap. This is why at least a portion of the trench top oxide is doped in the inventive structure. The inventive trench

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top oxide deposition process was developed to provide good dopant control in the oxide, to consistently achieve this structure.

To further shrink the vertical DRAM cell, with the invention, the lateral outdiffusion of the buried strap is reduced to avoid interaction between adjacent DRAM cells, while still maintaining a low resistive path to the channel region of the vertical transistor. By reducing the thermal budget of the entire process through multiple heating steps, the invention outdiffuses dopant from the doped trench top oxide layer and reduces the outdiffusion of the buried strap. Thus, both lateral and vertical outdiffusions are reduced. Sufficient overlap between the buried strap and the transistor channel is not assured with conventional processes that only rely upon outdiffusion from the trench conductor and the node strap to form the buried strap. This is why a portion of the trench top oxide is doped in the inventive structure.

Therefore, as shown above, Chang does not teach or suggest many of the claimed features in the invention including "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" as defined by independent claim 12. Therefore, Applicants submit that independent claim 12 is patentable. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

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D. The Rejection Based on Divakaruni

Applicants respectfully traverse this rejection because Divakaruni only discloses an initial heating process that forms the conductive strap and does not disclose the additional claimed heating process that is performed after the first conductive strap is formed and that forms the second conductive strap of the claimed invention.

More specifically, as explained in column 5, lines 36-39, of Divakaruni, an initial thermal oxidation process causes dopants from the conductor 20 to diffuse and form shallow junction region 200 in the substrate 22. In Divakaruni there are no additional heating processes that are performed after the shallow junction region 200 is formed that would allow a second conductive strap to be formed from dopants diffusing out from the trench top oxide 100. To the contrary, in the claimed invention, after the conductive buried strap and trench top oxide are formed, the structure is subjected to a second heating process that outdiffuses dopants from the trench top oxide to form a second conductive buried strap in the substrate that is connected to the first buried strap. More specifically the independent claims define this process using the following language: "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" independent claim 18.

Thus, the invention utilizes multiple heating steps to form the different portions of the buried strap, which allows lower temperature processes to be applied. With the invention, the higher temperatures normally needed to cause a larger buried strap outdiffusion can be avoided

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because the buried strap outdiffusion does not need to be as large with the invention. Normally, the buried strap outdiffusion needs to be made large enough to make the silicon next to the trench top oxide conductive. However, the inventive multiple heating step approach and doped trench top oxide outdiffusion allows the buried strap outdiffusion to be smaller (utilizing lower temperature thermal cycles) by providing a separate conductive region adjacent the trench top oxide. Thus, the temperature of the thermal cycles (thermal budget) can be reduced. To the contrary, conventional processes that only rely upon outdiffusion from the trench conductor and the node strap to form the buried strap must use substantially higher temperatures to achieve a conductive region adjacent the trench top oxide.

To further shrink the vertical DRAM cell, the lateral and vertical outdiffusion from the polysilicon strap is reduced (using lower temperature thermal cycles) to avoid interaction between adjacent DRAM cells while still maintaining a low resistive path to the channel region of the vertical transistor. Along with reducing the outdiffusion from the conductive strap, the invention outdiffuses dopant from the doped trench top oxide layer to ensure that a conductive path exists from the capacitor conductor to the channel. To assure good isolation between the conductors, and sufficient process control for the oxide deposition, the trench top oxide, should have a certain thickness. Considering that the process tolerance is +/- 100a, sufficient overlap between the conductive region and transistor channel is not assured with conventional processes that only rely upon outdiffusion from the trench conductor and the node strap. This is why at least a portion of the trench top oxide is doped in the inventive structure. The inventive trench top oxide deposition process was developed to provide good dopant control in the oxide, to

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consistently achieve this structure.

To further shrink the vertical DRAM cell, with the invention, the lateral outdiffusion of the buried strap is reduced to avoid interaction between adjacent DRAM cells, while still maintaining a low resistive path to the channel region of the vertical transistor. By reducing the thermal budget of the entire process through multiple heating steps, the invention outdiffuses dopant from the doped trench top oxide layer and reduces the outdiffusion of the buried strap. Thus, both lateral and vertical outdiffusions are reduced. Sufficient overlap between the buried strap and the transistor channel is not assured with conventional processes that only rely upon outdiffusion from the trench conductor and the node strap to form the buried strap. This is why a portion of the trench top oxide is doped in the inventive structure.

Therefore, as shown above, Divakaruni does not teach or suggest many of the claimed features in the invention including "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" as defined by independent claim 18. Therefore, Applicants submit that independent claim 18 is not anticipated by Divakaruni and are patentable over Divakaruni. Further, dependent claims 19 and 21 are similarly patentable, not only because they depend from a patentable independent claim, but also by virtue of the additional features of the invention they define. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

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E. The Rejection Based on Mandelman '886 and M'Saad

As shown above, Mandelman '886 does not teach or suggest the additional claimed heating process that is performed after the first conductive strap is formed and that forms the second conductive strap of the claimed invention. M'Saad also does not teach this feature and is not referenced for teaching this feature, but instead is referenced for teaching many common processes for performing chemical vapor deposition. Therefore, no combination of Mandelman '886 and M'Saad would teach or suggest "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" as defined by independent claims 12 and 18. Therefore, Applicants submit that independent claims 12 and 18 are patentable over the proposed combination of Mandelman '886 and M'Saad. Further, dependent claims 13-15, 21, and 22 are similarly patentable, not only because they depend from a patentable independent claim, but also by virtue of the additional features of the invention they define. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

F. The Rejection Based on Mandelman '862 and M'Saad

As shown above, Mandelman '862 does not teach or suggest the additional claimed heating process that is performed after the first conductive strap is formed and that forms the

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second conductive strap of the claimed invention. M'Saad also does not teach this feature and is not referenced for teaching this feature, but instead is referenced for teaching many common processes for performing chemical vapor deposition. Therefore, no combination of Mandelman '862 and M'Saad would teach or suggest "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" as defined by independent claims 12 and 18. Therefore, Applicants submit that independent claims 12 and 18 are patentable over the proposed combination of Mandelman '862. Further, dependent claims 13-15, 21, and 22 are similarly patentable, not only because they depend from a patentable independent claim, but also by virtue of the additional features of the invention they define. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

G. The Rejection Based on Chang and M'Saad

As shown above, Chang does not teach or suggest the additional claimed heating process that is performed after the first conductive strap is formed and that forms the second conductive strap of the claimed invention. M'Saad also does not teach this feature and is not referenced for teaching this feature, but instead is referenced for teaching many common processes for performing chemical vapor deposition. Therefore, no combination of Chang and M'Saad would teach or suggest "after forming said first conductive buried strap and forming said doped trench

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top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" as defined by independent claim 12. Therefore, Applicants submit that independent claim 12 is patentable over the proposed combination of Chang and M'Saad. Further, dependent claims 13-15 are similarly patentable, not only because they depend from a patentable independent claim, but also by virtue of the additional features of the invention they define. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

H. The Rejection Based on Divakaruni and M'Saad

As shown above, Divakaruni does not teach or suggest the additional claimed heating process that is performed after the first conductive strap is formed and that forms the second conductive strap of the claimed invention. M'Saad also does not teach this feature and is not referenced for teaching this feature, but instead is referenced for teaching many common processes for performing chemical vapor deposition. Therefore, no combination of Divakaruni and M'Saad would teach or suggest "after forming said first conductive buried strap and forming said doped trench top oxide, heating said device to form a second conductive buried strap in said substrate adjacent and connected to said first conductive buried strap" as defined by independent claim 18. Therefore, Applicants submit that independent claim 18 is patentable over the proposed combination of Divakaruni and M'Saad. Further, dependent claim 22 is similarly patentable, not only because it depends from a patentable independent claim, but also by virtue of

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the additional features of the invention it defines. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

III. Formal Matters and Conclusion

In view of the foregoing, Applicants submit that claims 12-19 and 21-31, all the claims presently pending in the application, are patentably distinct from the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary?

Please charge any deficiencies and credit any overpayments to Attorney's Deposit Account Number 09-0458.

Respectfully submitted,

Dated: 12/8/04

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